THE IMPACT OF SUPRAGLOTTIC AIRWAY USE ON OUT-OF-HOSPITAL OROTRACHEAL INTUBATION

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ABSTRACT

Objective: Orotracheal intubation is a mainstay of prehospital airway management and is a critical life-saving skill of paramedics. The impact of a new generation of supraglottic airway on orotracheal intubation success rate is unknown. This is an issue of public health importance because if orotracheal intubation success has decreased, this places the public at risk of adverse events. A lower success rate would require additional health care resources directed to improving the training or skills maintenance of paramedics. This would necessitate a multidisciplinary approach spanning the domains of health policy, risk communication, intervention planning and evaluation and biostatistics. I aim to determine whether orotracheal intubation success rates have changed since the introduction of a new generation of supraglottic airway, the King LTD, in an EMS system.

Methods: This was a retrospective before and after observational study of 36 EMS services in a 10-county region. Cases between Jan. 1, 2005 and Dec. 31, 2012 were included if there was an advanced airway procedure performed. The proportion of cases with first pass success was compared before and after the

King LTD was introduced in 2007. A secondary outcome was the proportion of cases ultimately managed with orotracheal intubation.

Results: The proportion of cases with first pass success did not change before and after 2007. The proportion of cases ultimately managed with orotracheal intubation decreased significantly.

Conclusion: Fewer patients ultimately received orotracheal intubation after the introduction of the King LTD, although orotracheal intubation success rates did not change. Supraglottic airways may primarily provide an alternative to further orotracheal intubation attempts in the prehospital setting. Continuing public health surveillance of the changing landscape of prehospital airway management will be important as new airway devices are introduced.

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PREFACE

The investigation was supported by the SAEM/Physio-Control EMS Fellowship.

1.0 BACKGROUND

Orotracheal intubation is the primary method to definitively secure a compromised airway and is a key component of advanced life support care provided by paramedics in the United States.[1-6] However, paramedics infrequently perform this procedure and may have limited training and skill retention.[2,5,7-15] As a result, intubation success rates by paramedics are low in many EMS systems, especially in non-cardiac arrest settings.[6,8,16-26] Due to long procedure times and low success rates, orotracheal intubation by paramedics has been associated with adverse patient outcomes in both non-cardiac arrest[17,24,27] and cardiac-arrest situations.[28,29]

Supraglottic airway devices provide an alternative method of airway management, and have increasingly been used across EMS systems in the past decade.[30,31] The King LTD (King Systems, Noblesville, IN) is part of a new generation of supraglottic airway devices that have gradually replaced previous versions, such as the Combitube (Covidien, Mansfield, MA), due to its single lumen and improved ease of use.[32-34] As with other supraglottic airway devices, the King LTD may have advantages over endotracheal intubation, including rapid and successful placement by providers with limited training, [31-33,35-44] especially in comparison with orotracheal intubation.[31,41,42,45-47] [36,37] Considering these potential advantages, supraglottic airway devices have been used both as rescue airway devices and as primary airway devices.[31,43]

In the years prior to 2007, EMS protocols recommended orotracheal intubation and supraglottic airways as management options for advanced airway interventions. Historically, orotracheal intubation was the preferred method of airway control, with supraglottic airways being used in rescue situations after failed attempts at orotracheal intubation. When a new supraglottic device, the King LTD, was introduced into the Southwestern Pennsylvania EMS services in 2007, there were a number of reasons to believe that it might be preferentially be used compared to orotracheal intubation. Minimal initial training and continuing education is required for successful placement of the device and it can be placed quicker than an endotracheal tube. Orotracheal intubation is a difficult skill, requiring frequent performance to be proficient.

The impact of this new generation of supraglottic airway devices on the performance of out-of-hospital orotracheal intubation is unknown. We aimed to determine whether out-of-hospital orotracheal intubation success rates have changed since the introduction of the King LTD in a regional EMS system that previously only used the Combitube as a rescue device. We hypothesized that out-of-hospital orotracheal intubation success rates have decreased since the introduction of the King LTD airway because King LTD airways would replace attempts at orotrahceal intubation.

2.0 METHODS

2.1 STUDY SETTING

This study evaluated data from 36 urban, suburban and rural ground EMS agencies in the ten county Southwestern Pennsylvania Emergency Medical Services (EMS) region. These services received medical direction from one academic medical center. Before 2007, paramedics in these EMS agencies followed agency-specific protocols based on region-wide guidelines. These guidelines specified use of advanced airways in medical and traumatic cardiac arrests, and directed the use of supraglottic airway devices primarily as rescue devices, after unsuccessful orotracheal or nasotracheal intubation. These were replaced in 2007 with statewide protocols, which similarly allowed for advanced airways to be used in medical and traumatic cardiac arrests, including use of orotracheal intubation, nasotracheal intubation or supraglottic devices. Statewide protocols required the use of a supraglottic rescue device, surgical airway or bag-valve-mask ventilation after two failed endotracheal intubation attempts. Video laryngoscopy was optional in the latter study period.

2.2 STUDY DESIGN

This was a retrospective before and after observational study of advanced airway management procedures. We reviewed the prehospital medical records

from these agencies, which use a common electronic patient care reporting program (emsCharts, Pittsburgh, PA). This study had Institutional Review Board approval.

We reviewed medical records between 2005 and 2012, which included two years before and 5 years after the introduction of the King LTD into this regional EMS system. Prior to 2007, these EMS agencies primarily used the Combitube, which was solely utilized as a rescue airway device in the case of a failed endotracheal intubation. All cases involving an advanced airway procedure were identified using custom reporting software in emsCharts and included in the cohort. Advanced airway was defined as orotracheal intubation, King LTD, Combitube, surgical airway, nasotracheal intubation and video laryngoscopy. Video laryngoscopy was categorized separately from orotracheal intubation. Included were all cases meeting the inclusion criteria between January 1, 2005 and December 31, 2006 and between January 1, 2008 and December 31, 2012. Patient complaint or provider impression was not specified and therefore the population includes patient records of all types, including cardiac arrest and non-cardiac arrest, medical and trauma records. Pediatric patients (<18 years of age) were not included.

The primary outcome was first pass success rate of orotracheal intubation and the secondary outcome was the type of final advanced airway device. First pass success was defined as a successful single endotracheal intubation attempt when performed as the first advanced airway securing method, as recorded by the paramedic. Final advanced airway device was defined as the final successful

advanced airway device used that was present until patient disposition, as recorded by the paramedic. Additional data collected included the number and type of all advanced airway devices placed per year. For data analysis, we included the largest time period possible (2005-2012) in our study to make it a comprehensive evaluation of airway management.

2.3 DATA ANALYSIS

Data were analyzed using Stata 13.1 (StataCorp LP, College Station, TX). Figures and tables were prepared using Excel 14.3.9 (Microsoft Corporation, Redmond, WA). The proportion of cases with first pass orotracheal intubation success and the proportion of cases with a final airway of orotracheal intubation were compared before and after 2007 using Pearson's chi-square analysis. The level of significance was set to 5%. Cases from 2007 were excluded as a run-in period accounting for King LTD introduction into the EMS system.

3.0 RESULTS

Of the 4100 cases that met inclusion criteria, 555 were from 2007 and were excluded (Figure 1). Of the remaining 3545 cases, 3,299 (93%) had an intubation attempt and 698 (19.7%) had a supraglottic device attempt. The

proportion of advanced airway attempts that were orotracheal intubation decreased from 91% in 2005 to 77% in 2012 (Figure 2).The proportion of airway attempts that were supraglottic airways increased from 4.2% in 2005 to 15.8% in 2012. The proportion of airway attempts that were via nasotracheal intubation was 5.4% in 2005 and 0.8% in 2012. There was no appreciable use of surgical airway or of video laryngoscopy. Video laryngoscopy attempts were 0% for all years until 2012 when it was 6.8%.

Orotracheal intubation first pass success rate was 59.4% before 2007 and 59.9% after 2007 (p=0.823) (Table 1). First pass success rate was 57% in 2005, 58.3% in 2006, 57.8% in 2008, 60.3% in 2009, 55.5% in 2010, 58.5% in 2011, and 59.3% in 2012 (Figure 3). The first pass success rate of supraglottic airways was 87.3% in 2008, 83% in 2009, 85.3% in 2010, 83.2% in 2011 and 80% in 2012 (Figure 4).

The proportion of cases with orotracheal intubation as the final advanced airway was 73.5% before 2007 and 68.25% after 2007 (p=0.006). The proportion of cases with a supraglottic airway as the final advanced airway was 7.14% before 2007 and 18.05% after 2007 ($p<0.01$). The proportion of cases with any other final airway was 19.3% before 2007 and 13.7% after 2007 ($p<0.01$,Table 2, Figure 5). When a supraglottic airway was used, it was used as a primary airway in 33.5% of cases and as a rescue device in 66.5% of cases (Table 3).

4.0 DISCUSSION

Prehospital airway management is dynamic, with the introduction of new devices, airway protocols and training emphases. In this study, new supraglottic devices were not associated with changes in first-pass orotracheal intubation success but were associated with fewer airways ultimately being managed by orotracheal intubation. At the same time, the proportion of airways that were managed with supraglottic airways increased, indicating increased use of these devices since the newest generation of supraglottic airways have been introduced.

Orotracheal intubation first pass success rate did not change before versus after 2007. The success rates found in these periods (59.4% and 59.9%) are consistent with other studies, which have shown first pass success rates between 57% and 70%.[1,6,21] There was a significant decrease in the proportion of cases in which the final advanced airway was orotracheal intubation. In the same period, the use of all other advanced airways, except supraglottic airways, as the final airway also decreased.

We found that the proportion of airway attempts that were supraglottic has steadily increased over the past 7 years. During the same period, there has been a decreasing proportion of airway attempts that were orotracheal intubation. Considering that first pass orotracheal intubation success rates did not change in either study period, the decrease in attempts is unlikely to have been a result of improved first past success. Improved orotracheal intubation success, had it

occurred, would have led to decreased attempts because if orotracheal intubation is successful on first pass, then additional attempts are not needed to secure the airway. Because the decrease in attempts is unlikely to result from first-pass success improvement, then the decrease in attempts is likely to have been related to other factors, one of which may be the King LTD. After the introduction of the King LTD, the proportion of airways managed with supraglottic airways increased, while those with orotracheal intubation decreased.

Airway attempts with the King LTD seem to have been replacing attempts with orotracheal intubation. This is consistent with other findings in this study showing that supraglottic devices primarily were used as rescue airways and that fewer final airways were orotracheal intubations.

Interestingly, video laryngoscopy, which had not been used in our system from 2005 to 2011, represented 7% of airway attempts in 2012. Its effect on orotracheal intubation success rates and supraglottic airway use will require further study because video laryngoscopy may lead to improved orotracheal intubation success. On the other hand, it may make orotracheal intubation more complex, leading to an additional skill retention burden.

4.1 LIMITATIONS

Although containing many services encompassing in a large geographic area with varied settings (urban, suburban and rural) this study occurred in only one

medical direction system. This may limit the generalizability of the findings. This study used did not account for individual provider success or performance rate, limiting the generalizability of the findings only to EMS systems rather than to individual providers. We were unable to obtain the data for individual providers due to lack of feasibility and ability to obtain consent from each EMS provider, dating back to 2005. Additionally, the study does not include adjusted analysis, such as multivariate logistic regression, because factors that would be used for adjustment could not be obtained. These factors include provider age, experience, number of airway attempts per provider per year. Patient physiologic data and medical history was inconsistently recorded, as is typical in prehospital records. This would limit the use of such data in an adjusted analysis.

As this was an observational study, there may have been other factors not observed, recorded or identified that affected airway management by the EMS providers and, therefore, the results. Beyond this being a limitation resulting from the information available in the prehospital records, this is an inherent limitation in observational studies.

This was a retrospective of medical records, introducing information bias due to how paramedics enter data into emsCharts. Data that is potentially biased included success of airway procedures and number of attempts on each individual patient as there multiple ways to enter this data into emsCharts which can lead to error in entering this data or in interpreting this data. Additionally, over the course of the study, there were increasing numbers of services using emsCharts. While we believe that the practice patterns of the services were

similar, as they were exposed to similar training programs and used the same protocols, this may not have been the case. This may have led to information bias. This study included only electronic medical records as a convenience sample, leading to possible selection bias, although this adds to the generalizability of the study.

5.0 CONCLUSION

Fewer patients ultimately received orotracheal intubation after the introduction of the King LTD. We found no change in first-pass success rate of prehospital orotracheal intubation before versus after the introduction of the King LTD in this system. The King LTD may primarily provide an alternative to further orotracheal intubation attempts in the prehospital setting. Continuing public health surveillance of the changing landscape of prehospital airway management will be important as new airway devices are introduced.

APPENDIX: TABLES AND FIGURES

Table 1: Orotracheal Intubation First Pass Success Rates, %	
Before 2007	59.4
After 2007	59.9

p=0.823

Table 2: Final Advanced Airway, %			
	Orotracheal Intubation	Supraglottic Airway	Other
Before 2007	73.5*	7.1	19.3
After 2007	68.2*	18.1	13.7

*p=0.006

Table 3: Supraglottic Utilization, %	
Attempt as a primary airway	33.5
Attempt as a rescue airway	66.5

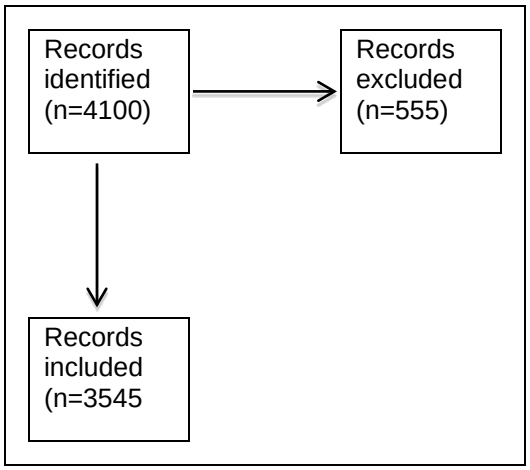

Figure 1: Records Included

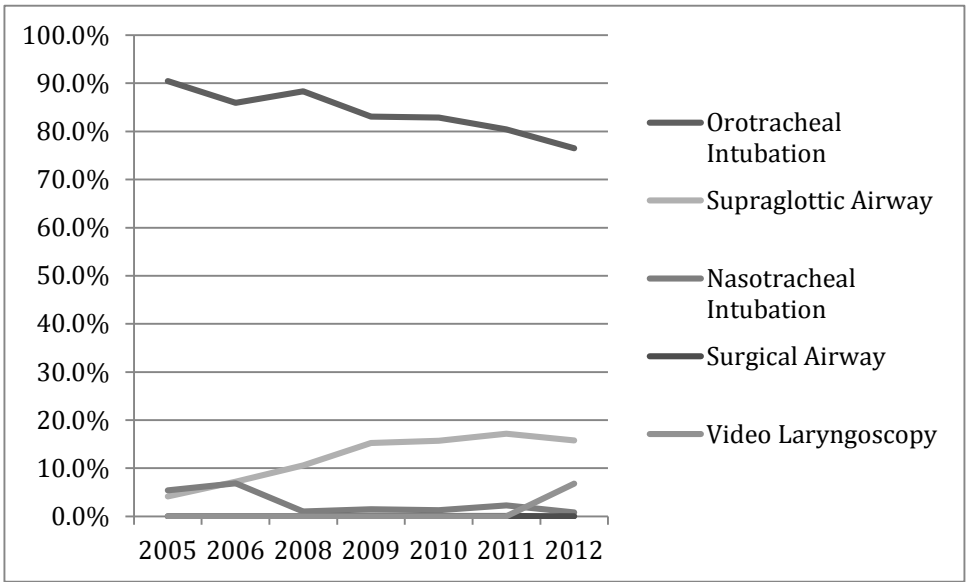

Figure 2: Percentage Airway Device Was Used in all Attempts by Year

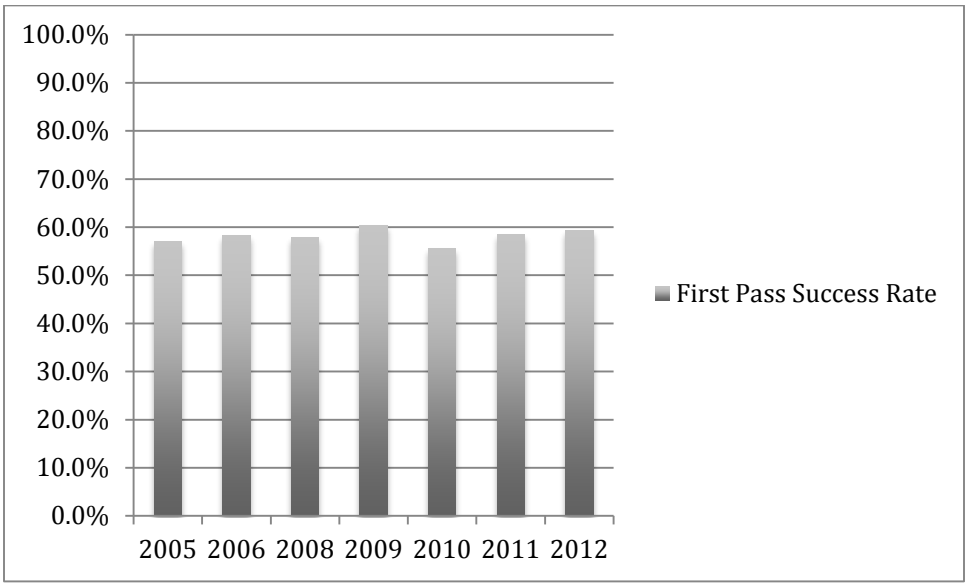

Figure 3: Orotracheal Intubation First Pass Success Rate by Year

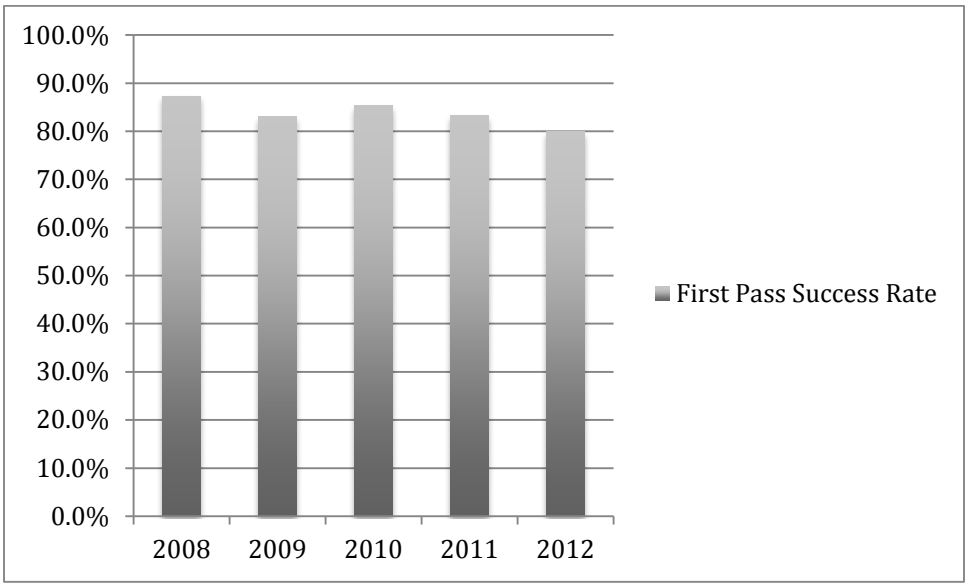

Figure 4: Supraglottic Airway First Pass Success Rate by Year, After 2007

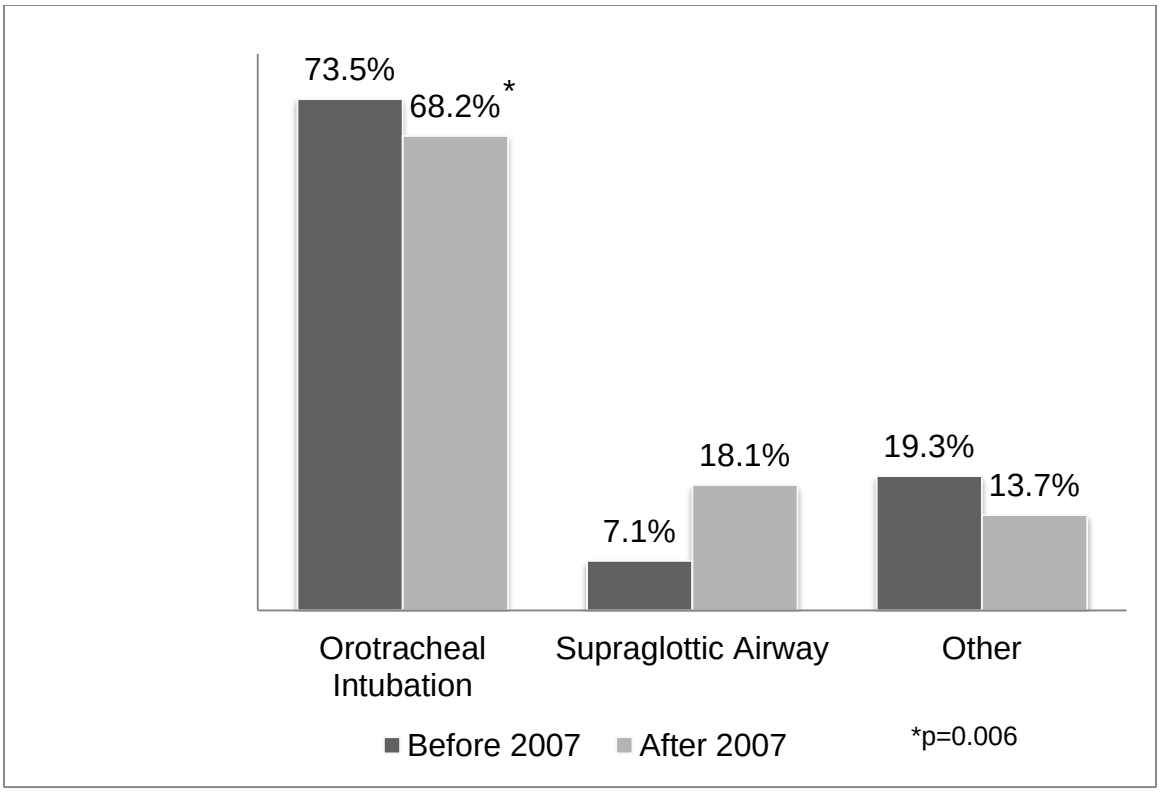

Figure 5: Final Airway

BIBLIOGRAPHY

1. Stewart RD, Paris PM, Winter PM, Pelton GH, Cannon GM. Field endotracheal intubation by paramedical personnel. Success rates and complications. Chest 1984;85:341-5.
2. Wang HE, Abo BN, Lave JR, Yealy DM. How would minimum experience standards affect the distribution of out-of-hospital endotracheal intubations? Ann Emerg Med 2007;50:246-52.
3. Wang HE, Balasubramani GK, Cook LJ, Yealy DM, Lave JR. Medical conditions associated with out-of-hospital endotracheal intubation. Prehosp Emerg Care 2011;15:338-46.
4. Nguyen HB, Daniel-Underwood L, Van Ginkel C, et al. An educational course including medical simulation for early goal-directed therapy and the severe sepsis resuscitation bundle: an evaluation for medical student training. Resuscitation 2009;80:674-9.
5. Wang HE, Yealy DM. Out-of-hospital endotracheal intubation: where are we? Ann Emerg Med 2006;47:532-41.
6. Davis DP, Fisher R, Buono C, et al. Predictors of intubation success and therapeutic value of paramedic airway management in a large, urban EMS system. Prehosp Emerg Care 2006;10:356-62.
7. Wang HE, Kupas DF, Hostler D, Cooney R, Yealy DM, Lave JR. Procedural experience with out-of-hospital endotracheal intubation. Crit Care Med 2005;33:1718-21.
8. Wang HE, Lave JR, Sirio CA, Yealy DM. Paramedic intubation errors: isolated events or symptoms of larger problems? Health Aff (Millwood) 2006;25:501-9.
9. Wang HE, Seitz SR, Hostler D, Yealy DM. Defining the learning curve for paramedic student endotracheal intubation. Prehosp Emerg Care 2005;9:156-62.
10. Raatiniemi L, Lankimaki S, Martikainen M. Pre-hospital airway management by non-physicians in Northern Finland -- a cross-sectional survey. Acta Anaesthesiol Scand 2013;57:654-9.
11. Warner KJ, Carlbom D, Cooke CR, Bulger EM, Copass MK, Sharar SR. Paramedic training for proficient prehospital endotracheal intubation. Prehosp Emerg Care 2010;14:103-8.
12. Wang HE, Balasubramani GK, Cook LJ, Lave JR, Yealy DM. Out-of-hospital endotracheal intubation experience and patient outcomes. Ann Emerg Med 2010;55:527-37 e6.
13. Deakin CD, King P, Thompson F. Prehospital advanced airway management by ambulance technicians and paramedics: is clinical practice sufficient to maintain skills? Emerg Med J 2009;26:888-91.

14. Johnston BD, Seitz SR, Wang HE. Limited opportunities for paramedic student endotracheal intubation training in the operating room. Acad Emerg Med 2006;13:1051-5.
15. Cady CE, Pirrallo RG. The effect of Combitube use on paramedic experience in endotracheal intubation. Am J Emerg Med 2005;23:868-71.
16. Wang HE, Mann NC, Mears G, Jacobson K, Yealy DM. Out-of-hospital airway management in the United States. Resuscitation 2011;82:378-85.
17. Colwell CB, McVaney KE, Haukoos JS, et al. An evaluation of out-of-hospital advanced airway management in an urban setting. Acad Emerg Med 2005;12:417-22.
18. Ochs M, Davis D, Hoyt D, Bailey D, Marshall L, Rosen P. Paramedic-performed rapid sequence intubation of patients with severe head injuries. Ann Emerg Med 2002;40:159-67.
19. Tam RK, Maloney J, Gaboury I, et al. Review of endotracheal intubations by Ottawa advanced care paramedics in Canada. Prehosp Emerg Care 2009;13:311-5.
20. Wang HE, Kupas DF, Paris PM, Bates RR, Yealy DM. Preliminary experience with a prospective, multi-centered evaluation of out-of-hospital endotracheal intubation. Resuscitation 2003;58:49-58.
21. Wang HE, Yealy DM. How many attempts are required to accomplish out-of-hospital endotracheal intubation? Acad Emerg Med 2006;13:372-7.
22. Wirtz DD, Ortiz C, Newman DH, Zhitomirsky I. Unrecognized misplacement of endotracheal tubes by ground prehospital providers. Prehosp Emerg Care 2007;11:213-8.
23. Jones JH, Murphy MP, Dickson RL, Somerville GG, Brizendine EJ. Emergency physician-verified out-of-hospital intubation: miss rates by paramedics. Acad Emerg Med 2004;11:707-9.
24. Wang HE, Cook LJ, Chang CC, Yealy DM, Lave JR. Outcomes after out-of-hospital endotracheal intubation errors. Resuscitation 2009;80:50-5.
25. Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med 2001;37:32-7.
26. Wang HE, Kupas DF, Paris PM, Bates RR, Costantino JP, Yealy DM. Multivariate predictors of failed prehospital endotracheal intubation. Acad Emerg Med 2003;10:717-24.
27. Dunford JV, Davis DP, Ochs M, Doney M, Hoyt DB. Incidence of transient hypoxia and pulse rate reactivity during paramedic rapid sequence intubation. Ann Emerg Med 2003;42:721-8.
28. Egly J, Custodio D, Bishop N, et al. Assessing the impact of prehospital intubation on survival in out-of-hospital cardiac arrest. Prehosp Emerg Care 2011;15:44-9.
29. Shy BD, Rea TD, Becker LJ, Eisenberg MS. Time to intubation and survival in prehospital cardiac arrest. Prehosp Emerg Care 2004;8:394-9.
30. Ostermayer DG, Gausche-Hill M. Supraglottic airways: the history and current state of prehospital airway adjuncts. Prehosp Emerg Care 2014;18:106-15.

31. Schalk R, Byhahn C, Fausel F, et al. Out-of-hospital airway management by paramedics and emergency physicians using laryngeal tubes. Resuscitation 2010;81:323-6.
32. Tumpach EA, Lutes M, Ford D, Lerner EB. The King LT versus the Combitube: flight crew performance and preference. Prehosp Emerg Care 2009;13:324-8.
33. Russi CS, Miller L, Hartley MJ. A comparison of the King-LT to endotracheal intubation and Combitube in a simulated difficult airway. Prehosp Emerg Care 2008;12:35-41.
34. Davis DP, Valentine C, Ochs M, Vilke GM, Hoyt DB. The Combitube as a salvage airway device for paramedic rapid sequence intubation. Ann Emerg Med 2003;42:697-704.
35. Larsen MJ, Guyette FX, Suyama J. Comparison of three airway management techniques in a simulated tactical setting. Prehosp Emerg Care 2010;14:510-4.
36. Burns JB, Jr., Branson R, Barnes SL, Tsuei BJ. Emergency airway placement by EMS providers: comparison between the King LT supralaryngeal airway and endotracheal intubation. Prehosp Disaster Med 2010;25:92-5.
37. Castle N, Owen R, Hann M, Naidoo R, Reeves D. Assessment of the speed and ease of insertion of three supraglottic airway devices by paramedics: a manikin study. Emerg Med J 2010;27:860-3.
38. Gahan K, Studnek JR, Vandeventer S. King LT-D use by urban basic life support first responders as the primary airway device for out-of-hospital cardiac arrest. Resuscitation 2011;82:1525-8.
39. Beauchamp G, Phrampus P, Guyette FX. Simulated rescue airway use by laypersons with scripted telephonic instruction. Resuscitation 2009;80:925-9.
40. Studer NM, Horn GT, Studer LL, Armstrong JH, Danielson PD. Feasibility of supraglottic airway use by combat lifesavers on the modern battlefield. Mil Med 2013;178:1202-7.
41. Hubble MW, Wilfong DA, Brown LH, Hertelendy A, Benner RW. A meta-analysis of prehospital airway control techniques part II: alternative airway devices and cricothyrotomy success rates. Prehosp Emerg Care 2010;14:515-30.
42. Ritter SC, Guyette FX. Prehospital pediatric King LT-D use: a pilot study. Prehosp Emerg Care 2011;15:401-4.
43. Guyette FX, Wang H, Cole JS. King airway use by air medical providers. Prehosp Emerg Care 2007;11:473-6.
44. Byars DV, Brodsky RA, Evans D, Lo B, Guins T, Perkins AM. Comparison of direct laryngoscopy to Pediatric King LT-D in simulated airways. Pediatr Emerg Care 2012;28:750-2.
45. Frascone RJ, Wewerka SS, Griffith KR, Salzman JG. Use of the King LTS-D during medication-assisted airway management. Prehosp Emerg Care 2009;13:541-5.
46. Nelson JG, Wewerka SS, Woster CM, Burnett AM, Salzman JG, Frascone RJ. Evaluation of the Storz CMAC(R), Glidescope(R) GVL, AirTraq(R), King LTS-

D, and direct laryngoscopy in a simulated difficult airway. Am J Emerg Med 2013;31:589-92.
47. Brown LH, Hubble MW, Wilfong DA, Hertelendy A, Benner RW. Airway management in the air medical setting. Air Med J 2011;30:140-8.